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Plan de Recuperación, Transformación y Resiliencia
GENERALITAT VALENCIANA
Conselleria de Educación, Universidades y Empleo
GVANEXT
Fondos Next Generation en la Comunitat Valenciana

Entendiendo el Universo a través de su Hidrógeno

Alberto Torralba Torregrosa

Observatori Astronòmic
VNIVERSITAT DE VALÈNCIA

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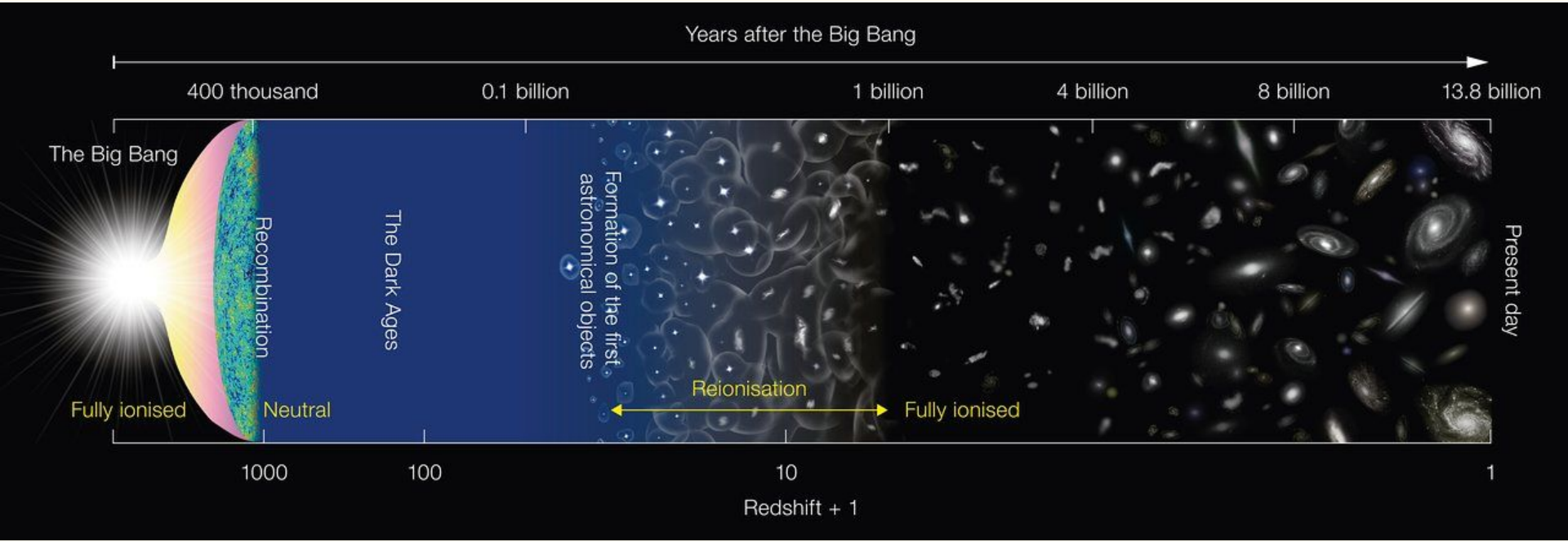
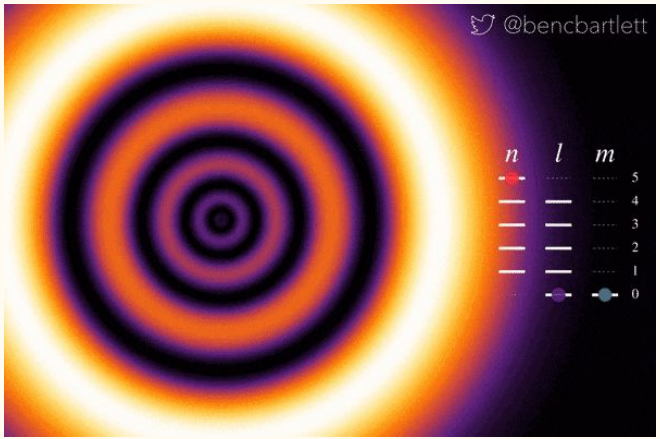
History of the Universe

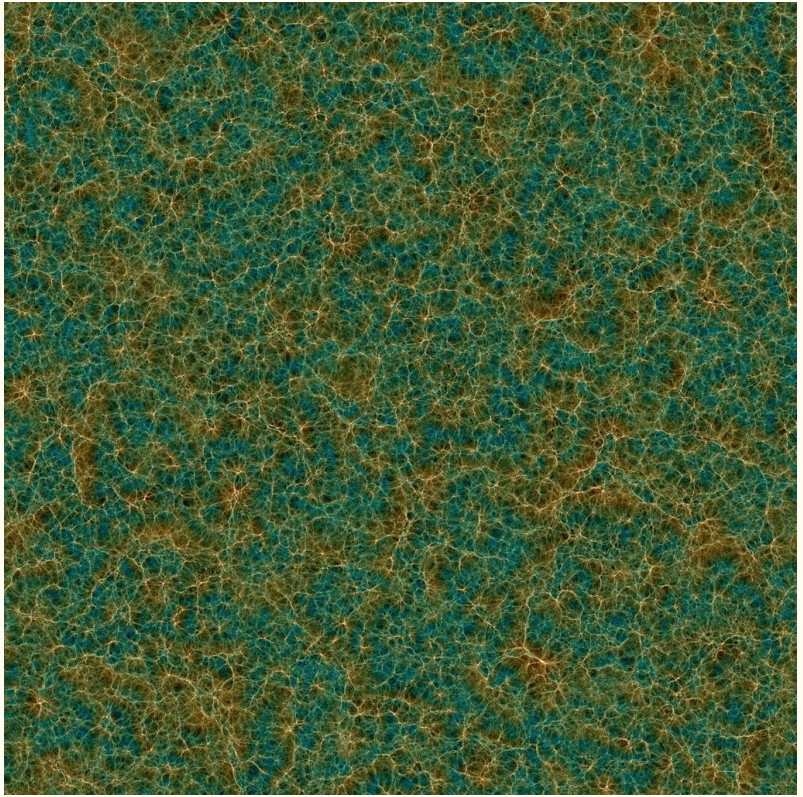


(https://simonsobservatory.org/recombination-and-reionization/)

Content of the Universe

- ~74% of our galaxy is Hydrogen
- ~90% of the content of the Universe

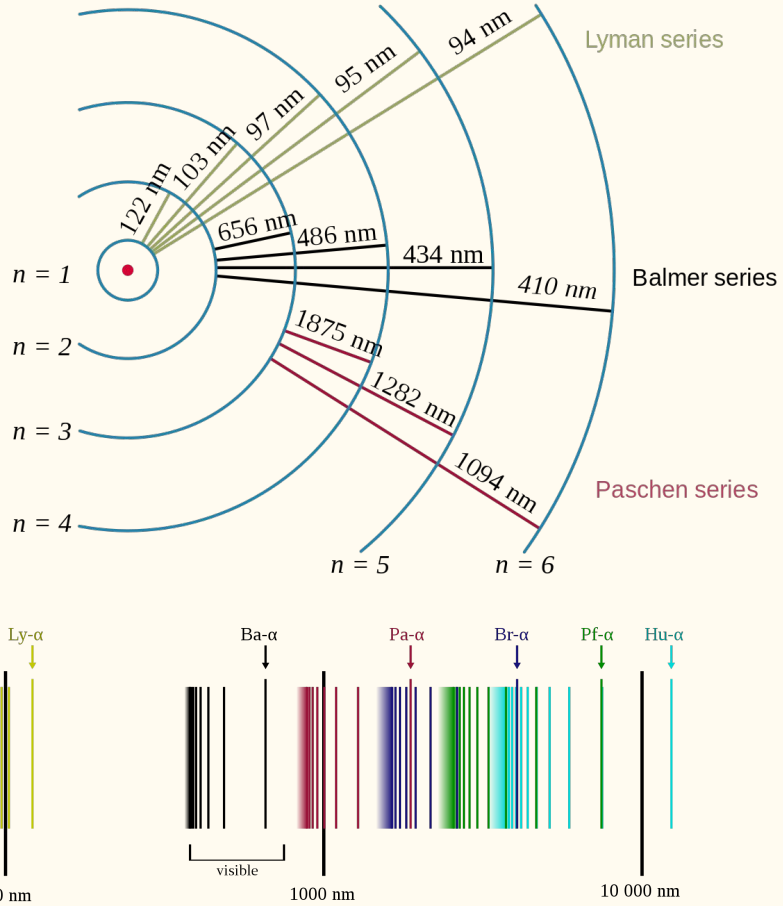




(https://hpc.imit.chiba-u.jp/~ishiymtm/uchuu.html)

Hydrogen lines

- They trace the properties of stars, interstellar medium, intergalactic medium...



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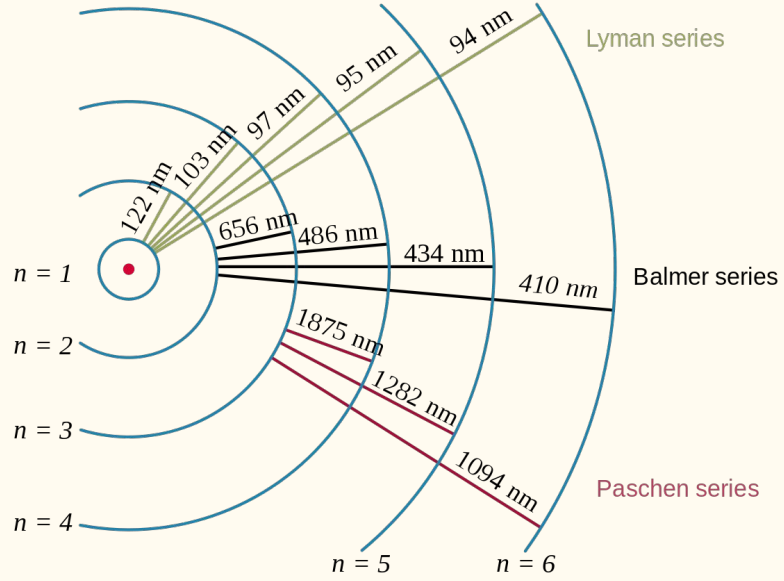
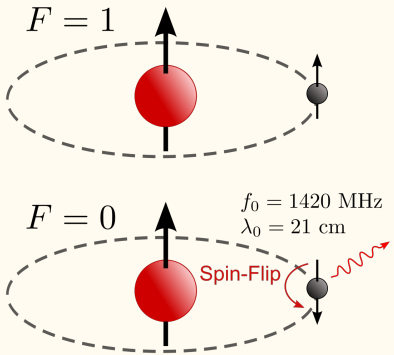
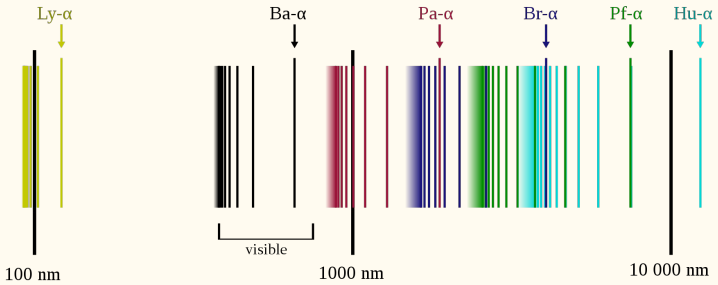


21-cm hyperfine transition line

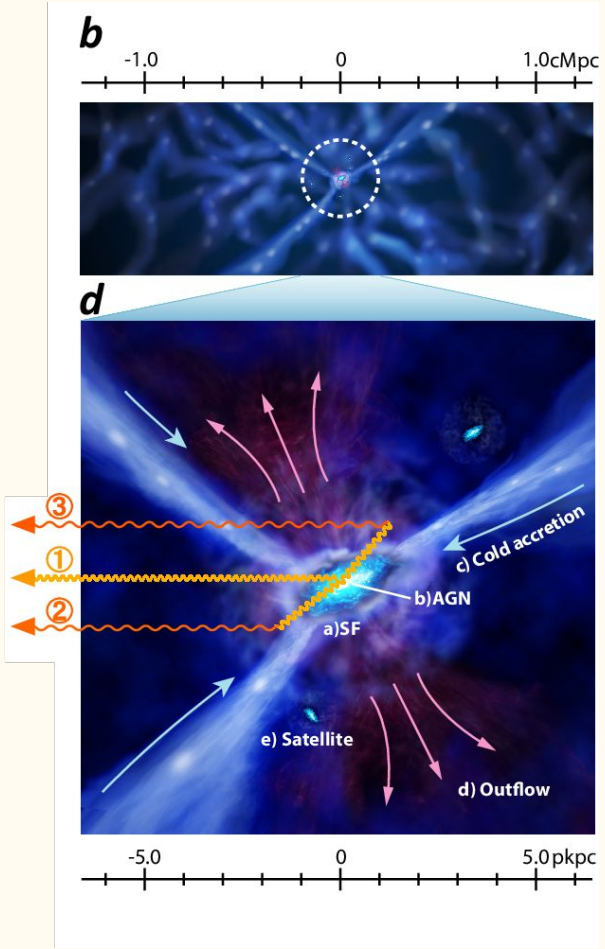




Lyman-alpha (n=2→1)

- Lyman-alpha emitters:
  - QSOs
  - Star-forming Galaxies

λ_0=1215.67 Å
Highly resonant with neutral H



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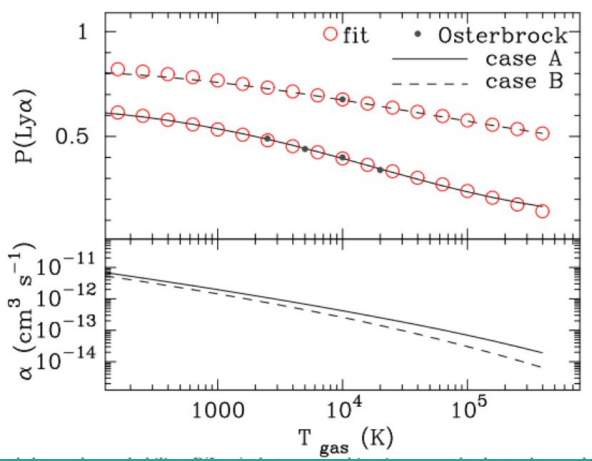
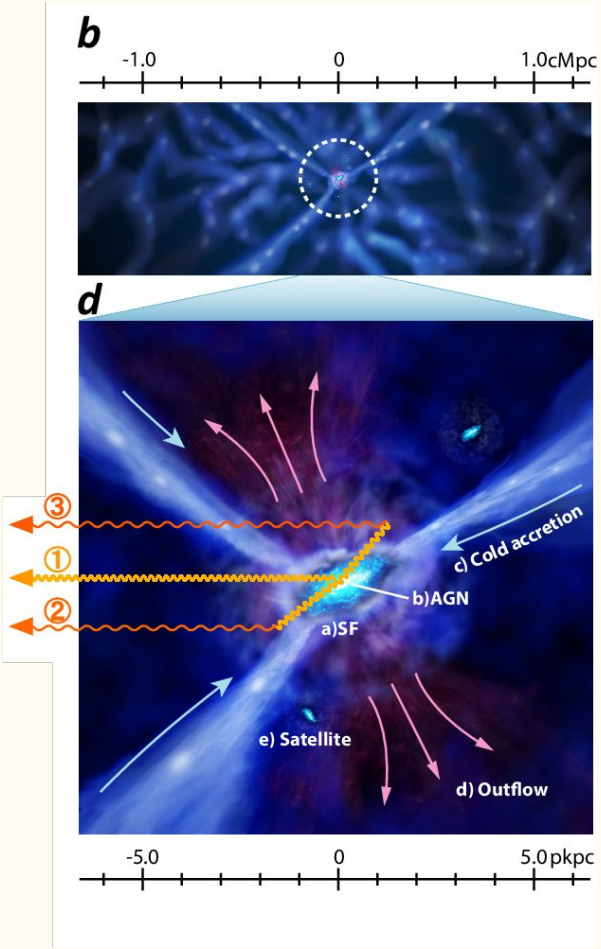


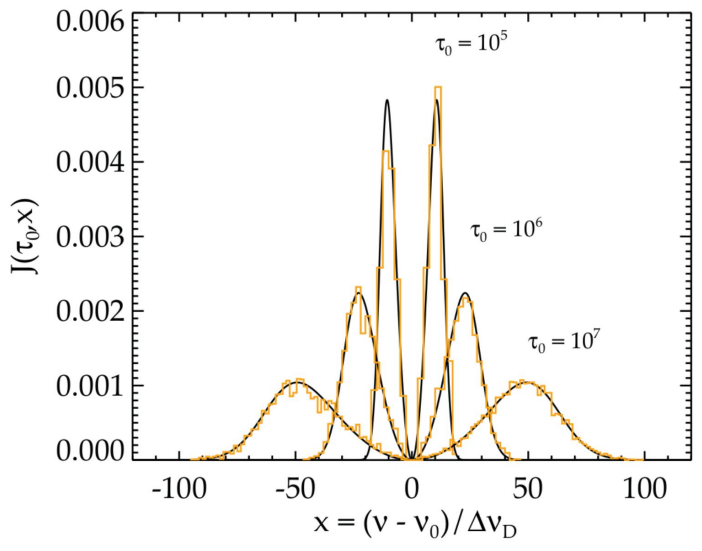
Dijkstra+2017



Ouchi+2020

The Lyman-alpha line: Line profile

Effect of the gas optical depth

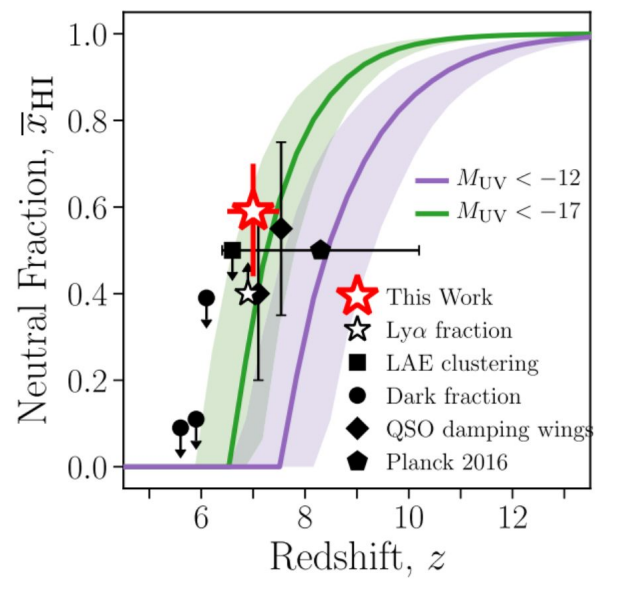


Dijkstra+2017

The Lyman-alpha line: Line profile

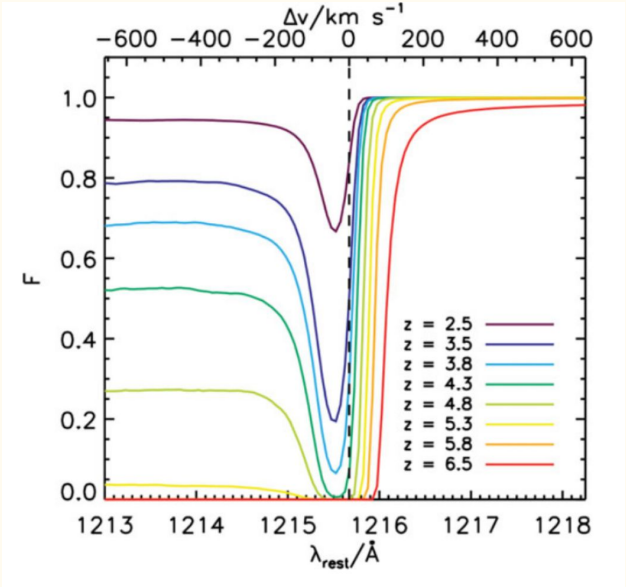
Intergalactic medium (IGM)

H neutral fraction



Mason+2018

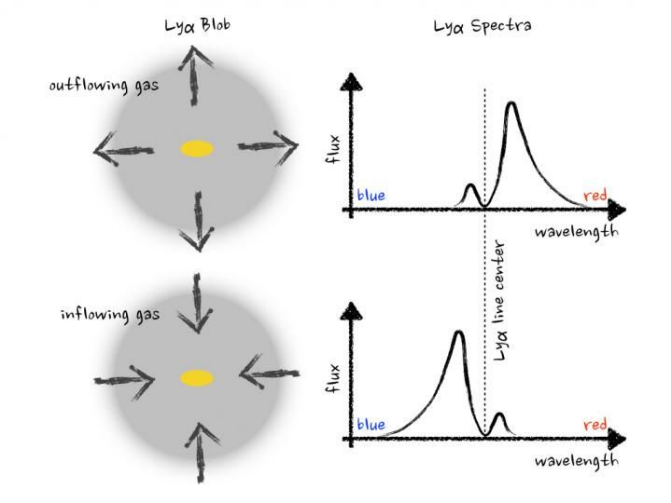
Lya absorption by IGM



Dijkstra+2017

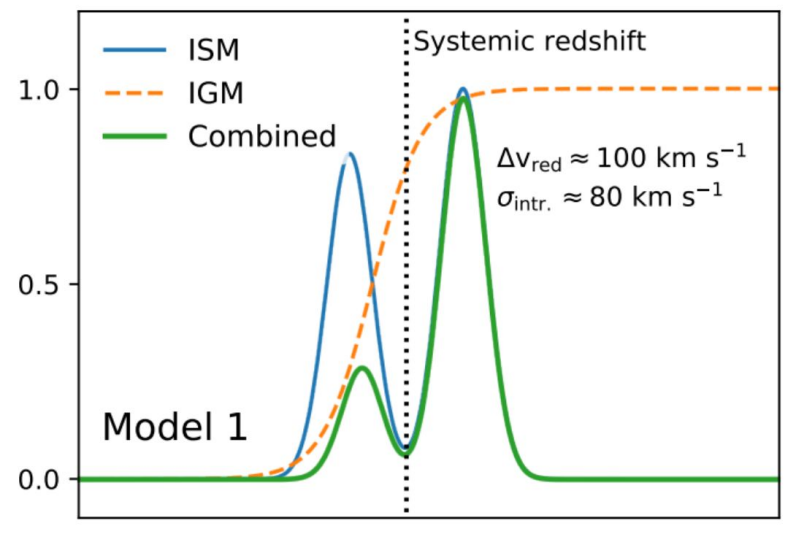
The Lyman-alpha line: Line profile

Outflows



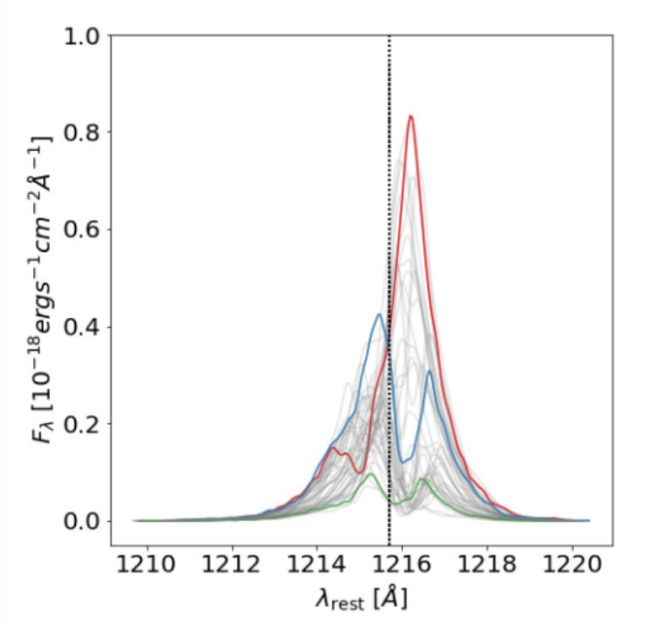
(Credit: Zheng Zheng,
https://www.eurekalert.org/multimedia/871268)

All combined

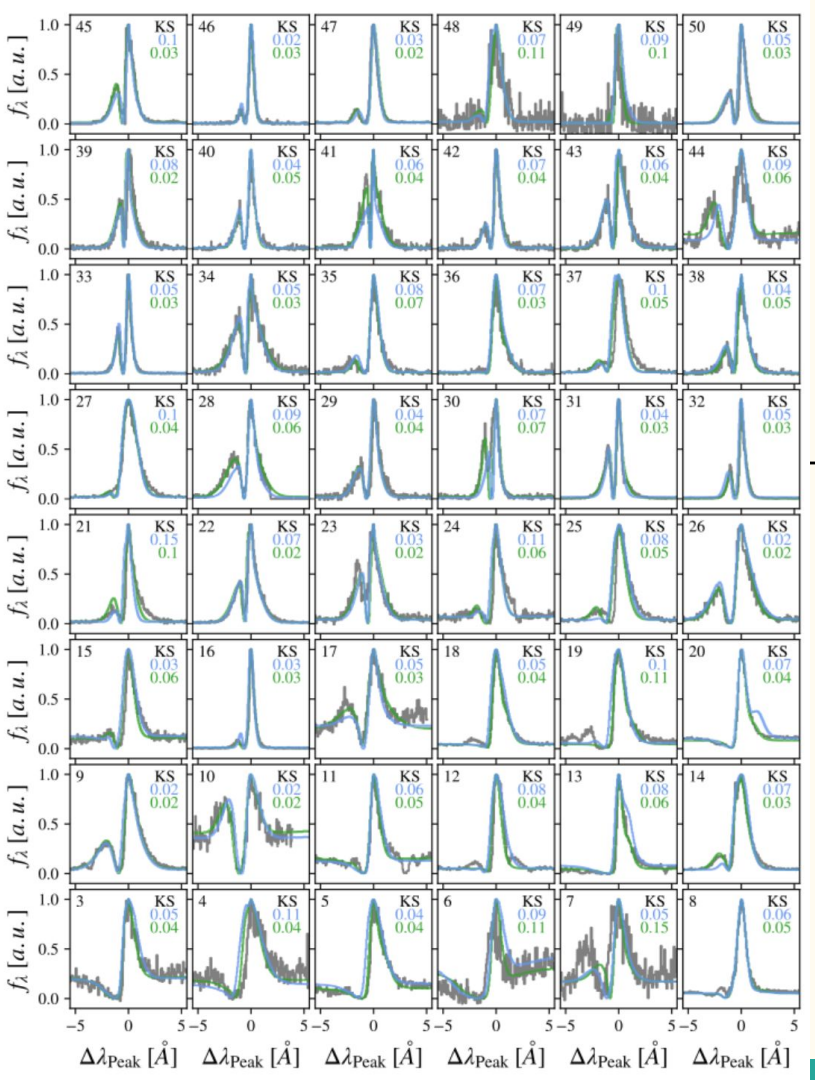


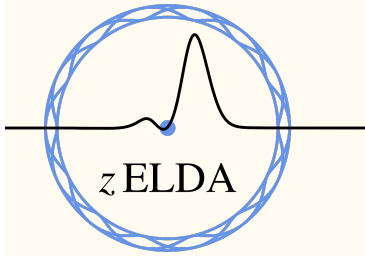
Matthee+2018

The Lyman-alpha line: Line profile



Giovinazzo+2024

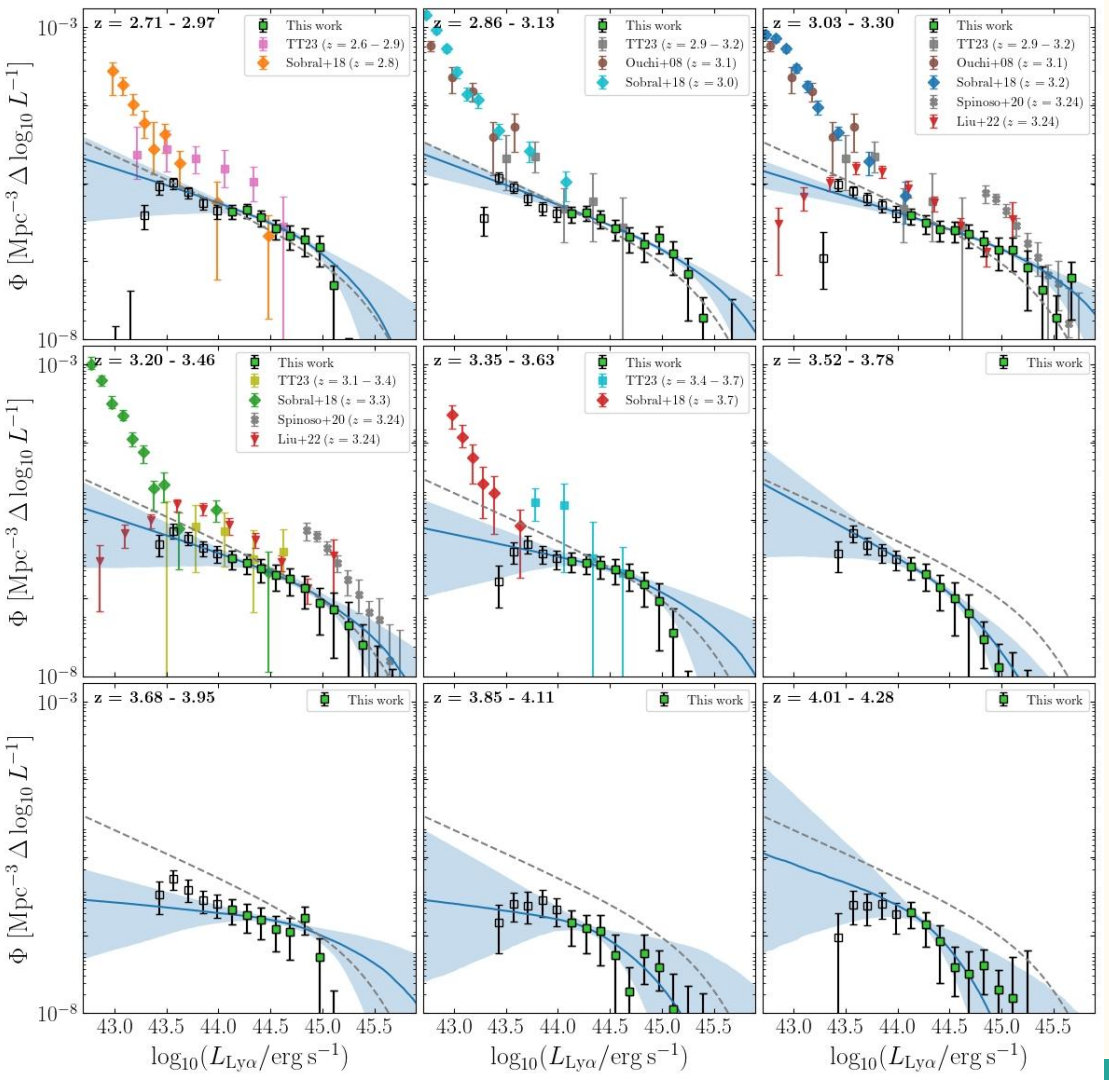




Gurung-López+22

Lyman-alpha luminosity function

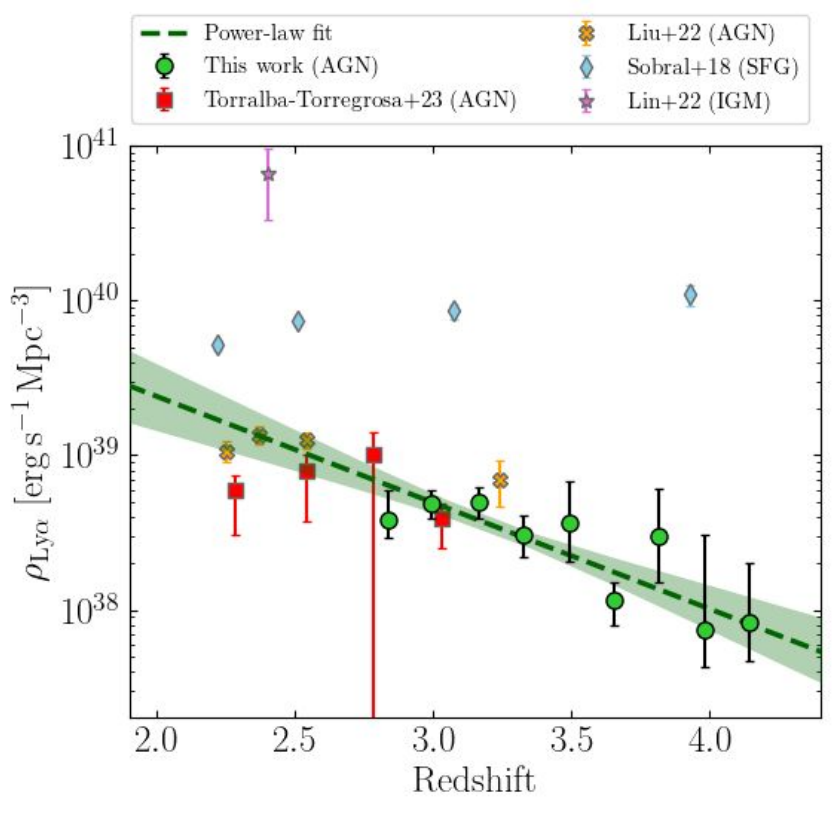
(In the multi-narrow band surveys: PAUS & J-PAS)



Torralba-Torregrosa+2023
Torralba Torregrosa+in prep.

Lyman-alpha luminosity function: Evolution

Work in progress

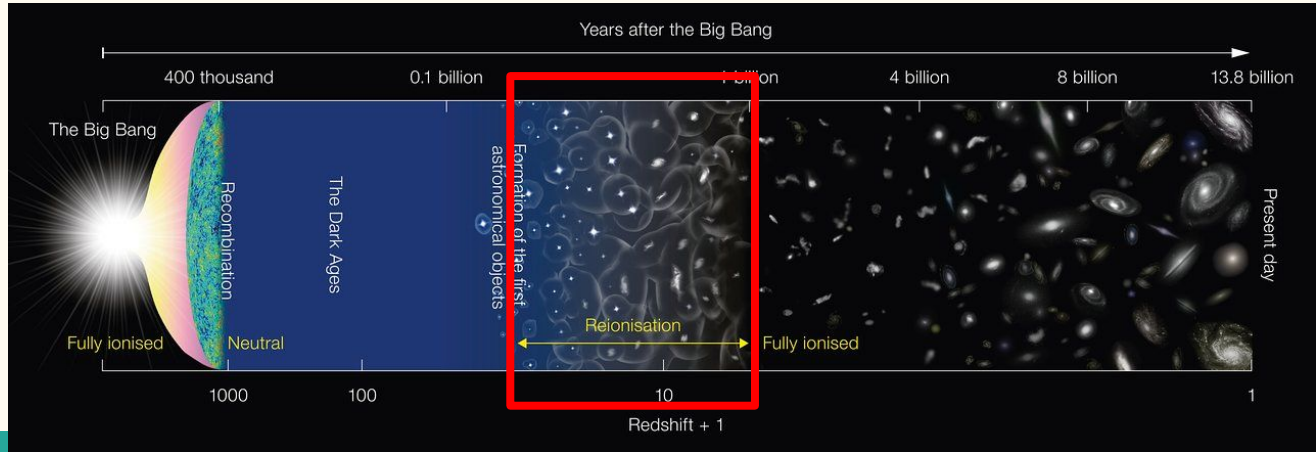


Torralba-Torregrosa+in prep.

Reionization of Hydrogen

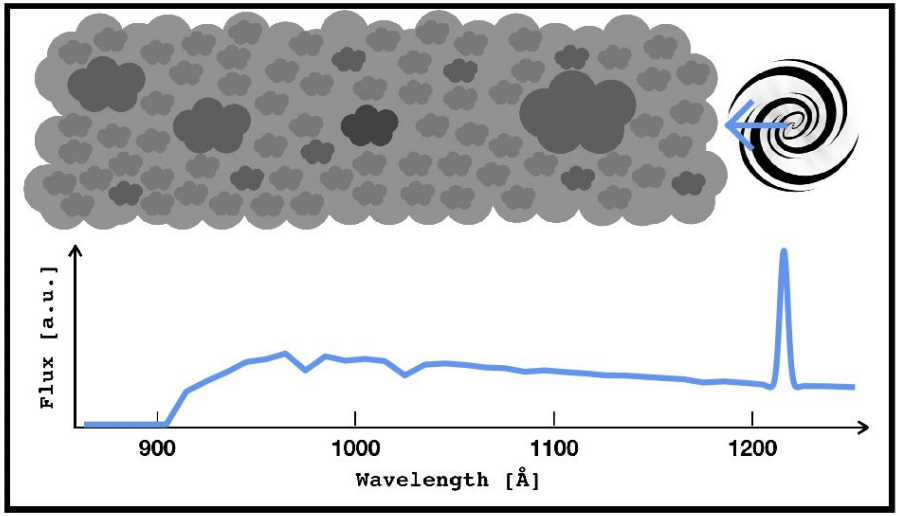
- Last major phase transition of the Universe

- Average Redshift: z = 7.8–8.8 (CMB, Planck 2020)
- Complete by z ~ 5.5 (QSO Lya forest, Gunn-Peterson trough)

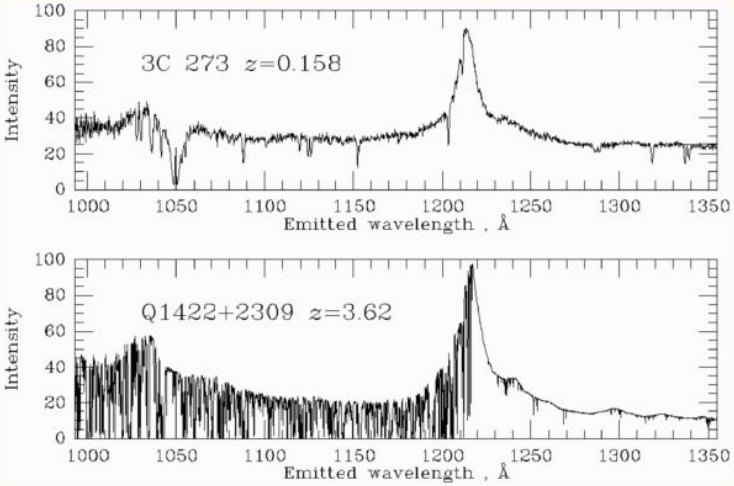


Lyman Forest

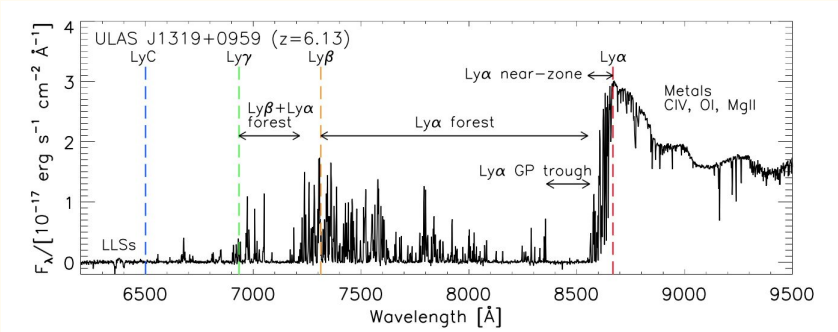
QSO spectra:



(Credit: S. Gurung-López)



(https://pages.astronomy.ua.edu/keel/agn/forest.html)



(Becker+2015)

Sources of reionization

- (Too) many candidates:
  - A few bright galaxies (Oligarchs)
  - Numerous faint galaxies (Democrats)
  - Active Galactic Nuclei
  - Formation of globular clusters
  - Short star formation bursts (disco-like reionization)
  - Uniform or “patchy” reionization?
- Problems:
  - Impossibility to directly measure escape fraction of ionizing photons (f_{esc}) at $z > 5.5$
  - Main ionizers might be too faint to be detected (even for JWST)

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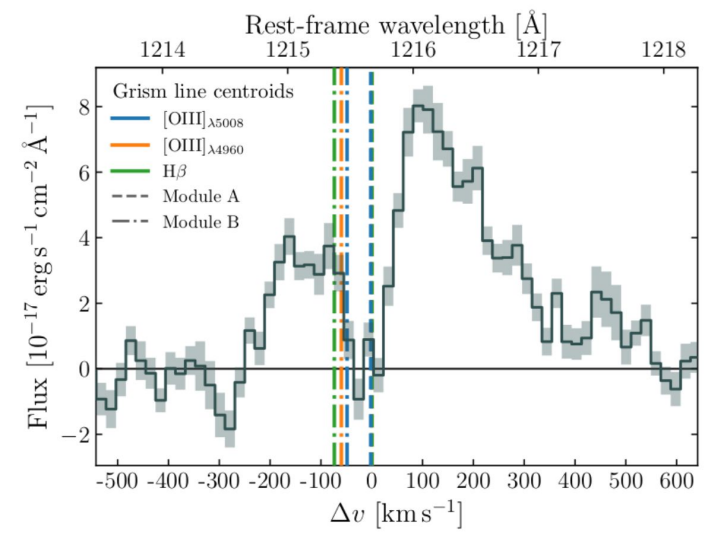
f_{esc}: Fraction of produced ionizing photons that make it out the ISM

The case of COLA1: a bright ionizing radiation leaker



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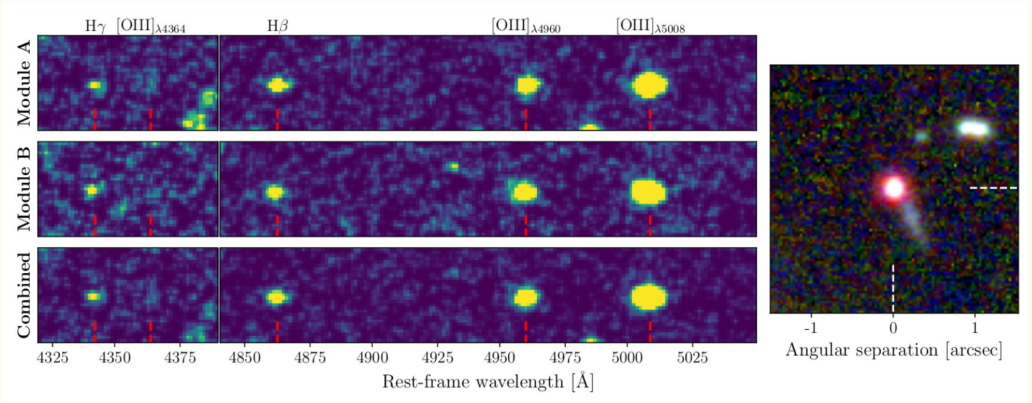
Double Lya peak at z = 6.6 ?!

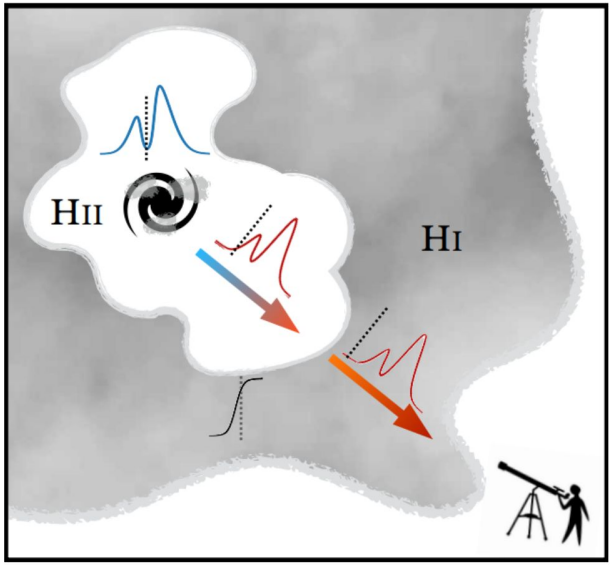
JWST Slitless Spectroscopy



Torralba-Torregrosa+in prep.

- Very compact ($r_{50} = 0.37$ kpc)
- High star formation rate
- Big ionizer ($f_{esc} = 20–50\%$)

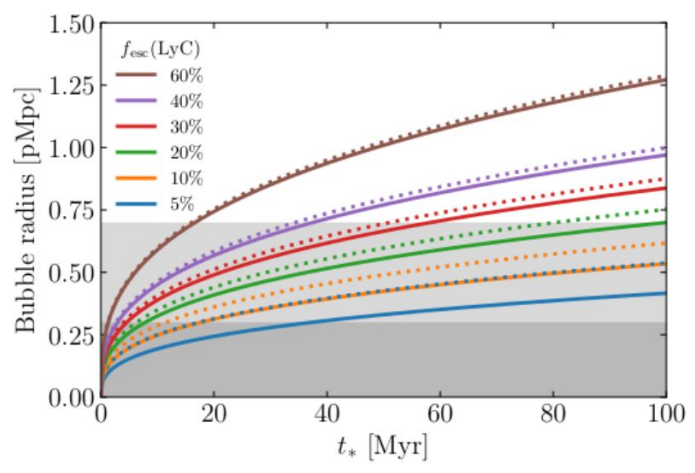
The case of COLA1: Ionized Bubble?



Matthee+2018

The case of COLA1: Ionized Bubble?

- An ionized HII region of ~0.7 Mpc (proper) would explain COLA1's double-peak Lyman-alpha



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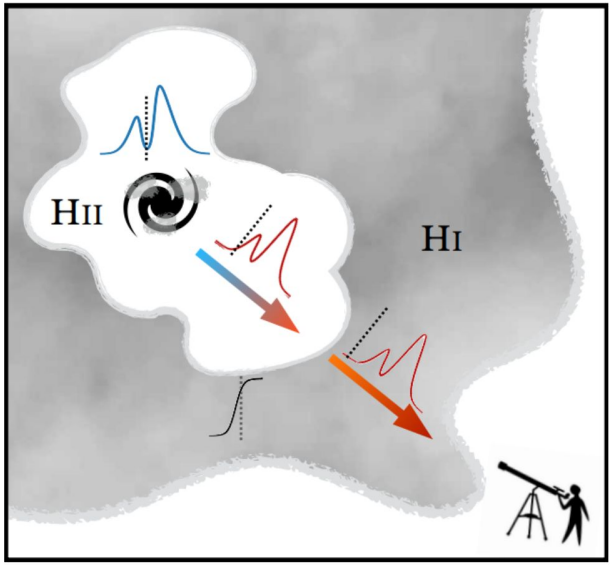

Matthee+2018

Thank you for your attention :)

- Contact: alberto.torralba@uv.es